CBDM, metrics, and level of detail

Lars O. Grobe, J. Alstan Jakubiec

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Background

Nima’s presentation in the previous session: Nima Forouzandeh. *Influence of inaccurate material optical properties and geometrical levels of detail on daylight simulation results - sensitivity analysis and uncertainty quantification*. 21st International Radiance Workshop, Innsbruck, Austria. Aug. 2023

• Context: Research in daylight metrics for dwellings
• What can metrics tell if they are computed from incomplete models
• Assumption: Furnishing etc. is unknown during building design

Refinements and CBDM


Level of Detail versus data availability


J.A. Jakubiec et al. “Subjective and measured evidence for residential lighting metrics in the tropics”. In: Building Simulation Conference. Vol. 2. 2019
Swiss Dwellings

- 42,207 apartments in 3,093 buildings comprising 242,257 rooms
- Geometry described by *Well-Known Text* (WKT)
- Conversion to Wavefront OBJ is possible
- Room typologies and daylight characteristics as room attributes
- No materials, no shading, no furnishing!
Recommendations


Daylight calculation should take into account (...) external surroundings, daylight openings (materials and components), and internal reflections (e.g. indoor surfaces and fixed objects). (...) If details of the space being assessed are not available, then reasonable assumptions may be employed (e.g. reflectance of indoor surfaces, indoor space configurations and furniture, if known). All assumptions made shall be stated.


Furniture and opaque interior partitions shall be modeled. Any partition or furniture element extending 36" above the floor or more shall be modeled to within 6" accuracy. If furniture layout and type are not known precisely, a typical furniture layout for that space type should be used. (...) Discussion: The location, geometry and reflectance of interior obstructions have an important influence on daylight distribution. For example, lowering the height of open office partitions from 60" to 45" can result in a 20 % increase in daylight availability in spaces with large windows.(...)
Detailed data from post-occupancy surveys

3D scans Alstan J.A. Jakubiec et al. “Subjective and measured evidence for residential lighting metrics in the tropics”. In: Building Simulation Conference. Vol. 2. 2019
Three Four LoDs

LoD4  Detailed model based on 3D scan, including building shell, environment, shades, and furniture

LoD3  As LoD4, but without furniture and wall reflectivity reduced to $\rho = 0.2$ to account for occlusion of wall surfaces

LoD2  As LoD4, but without furniture

LoD1  Only building shell and environment
Simulation with Raytraverse

Stephen W Wasilewski et al. “Raytraverse: Navigating the lightfield to enhance climate-based daylight modeling”. In: Proceedings SimAUD 2021. 2022. in press
Technicalities: Evaluating Raytraverse results

RAYTRAVERSE saves its results in packed NUMPY arrays:

```python
import numpy as np

# Load the archive and show its contents:
npz = np.load(npzFile)
print(npz.files)

# Print the names of arrays arr_0 to arr_3:
print(npz['names'])
```

[Image of the text page]
Technicalities: Evaluating Raytraverse results 2

Access the time stamps (month / day / hour of day):

```python
print(npz['arr_0'])
[(1., 1., 7.5) (1., 1., 8.5) (1., 1., 9.5) ...
(12., 31., 17.5) (12., 31., 18.5)]
```

Access the view directions ($\vec{dx}, \vec{dy}, \vec{dz}$):

```python
print("npz['arr_2']")
[(0.11440395, 0.99343431, 0.) (-0.99343431, 0.11440395, 0.)
(0.11440395, -0.99343431, 0.) (0.99343431, -0.11440395, 0.)]
```
Now we can have a look at the second time-step:

```python
print("npz['data_1'].shape")
(59, 4, 10)
print(npz['arr_3'])
['x', 'y', 'z', 'area', 'illum', 'avglum', 'gcr', 'dgp', 'log_gc', 'maxlum']
```

... and read the point illuminances for the first view direction:

```python
print (npz['data_1'][:,0,4])
```

**Spatial averaging**

Note the adaptive resolution – points represent different areas of the zone. Therefore, spatial averaging typically requires prior weighing with the area!

From here on, all processing is done with NUMPY, MATPLOTLIB and friends.
Frequency distributions of $E_h$, $E_v$

$E_h$ toward window

$E_v$ parallel to window

$E_v$ from window
Daylight provision

- Daylight Autonomy sDA\(^1\) was calculated for sensors at \(z = 0.80\) m with a threshold of 300 lx.
- Red line indicates the area meeting the criteria for 75% of daylight hours.

\(^1\)The legend shows sDA/DA as fraction 0 to 1 instead of percentage.
Ranking two rooms by sDA

Comparison of bedroom (blue) and living room (red) by sDA
And what about glare?

- Daylight Glare Probability DGP was calculated for sensors at $z = 1.60$ m toward four directions.
- Color indicates the fraction of daylight hours with $DGP \geq 0.35$ by evaluating the worst of the four directions.
- Red line indicates the area meeting the criteria for 95% of daylight hours.
- But: The chosen example exhibits almost no glare conditions due to the combination of overhang, North orientation, and location close to the equator.
Conclusions

• LoD moderately effected $E_h$ and derived sDA.
• Moderate effect on $E_v$ toward window for LoD2 to LoD4 (as long as shading is modelled).
• Strong effect on $E_v$ parallel to and facing away from window.
• Relative ranking of two rooms was consistent for all LoDs.
• Luminance-based metrics to be done.
• Expanding to include more cases necessary for representative results.

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